SOIL CONSERVATION

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A LOOK AT SOME OF THE WESTERN PROJECTS

By H. H. Bennett

Chief, Soil Conservation Service

Mr. Bennett.

The progress being made on the western soil-erosion demonstrations, which I have just visited, is most encouraging. Considering the brief period the work has been under way, the accomplishments thus far portend a veritable agricultural revolution—the throwing off of shackles of soil misuse and abuse that had their origin in a national misconception with respect to our supposedly inexhaustible supply of crop and grazing lands.

I saw unmistakable evidence that the hundreds of land users cooperating with the Service have come to understand the significance of cultivating and overgrazing all kinds of land, as if it all, steep and level, clay and sandy, were equally adapted to continuing productive use. The effective practices employed in the demonstration areas are beginning to trickle across the project boundaries. Farmers outside are beginning to work these new and fundamental soil-protection methods into their system of land use.

In the more humid parts of the great wheat belt of Washington, Idaho, and Oregon—the Palouse region, where rain and melting snow have been stripping off the better topsoil from the most productive wheat lands on earth—I saw numerous highly erodible fields planted to combinations of sweetclover, alfalfa, and grass, that is, to crops which not only stop erosion but cause the absorption of practically all of the rain and melting snow. Such use of the land, as a predominantly accepted farm practice, was the more astonishing to me because only 6 years ago I had with small success searched this same region for fields planted to just such.

In other words, virtually nothing was being done 6 years ago to control erosion in the Palouse country, although much was being done to encourage it. Now the countryside is erosion conscious, farmers are going into battle against the evil, and splendid headway is being made.

On the watershed of Palouse River, above Pullman, Wash., more than 10,000 acres, formerly used for wheat and peas under a system of summer fallowing (with approximately half of the cultivated area under clean summer fallow every year), have been planted to various combinations of sweetclover and grass and of alfalfa and grass. Probably this practice in itself saved annually more than a billion and a half gallons of water that formerly ran off as so much waste, and it has given full protection to lower lying areas over which detrimental erosional debris was being washed from exposed subsoil above. Many rapidly expanding gullies have been controlled, covered over, and seeded to stabilizing vegetation. This has obviated the necessity of making hazardous crossings and troublesome detours in operating heavy farm machinery.

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Gullying in bean field in Las Posas, Calif., project. The whiteness of the gully sides is due to exposure of the subsoil as a result of repeatedly cultivating after each rain.

Many of the larger ravines which had drained away subsoil moisture to such an extent that the productivity of the rich alluvial topsoil had greatly deteriorated, have been closed up with dams built by E. C. W. labor. Behind these dams, pools of water have collected. Normal water table conditions have been reestablished, and wild ducks have come to breed along ravines that only a little while ago were dry as desert arroyos, all summer long.

Retired and Stabilized

Numerous areas of severely washed land and land susceptible to destructive washing have been retired from cultivation and planted to trees or permanent grass. Much of this land was so steep that harvesting machinery had to be fitted with leveling devices to prevent overturning. In some places bedrock is now protruding where before there was a good depth of highly productive soil. I saw numerous flocks of sheep grazing on these "retired" lands, now stabilized with clover, alfalfa, and grass. The sheep were en route from high summer ranges to winter pastures, and the landowners were receiving grazing rentals that were highly pleasing to them.

Over in Oregon, Ed Hill has put a far-reaching erosion-control program into operation. In this region of superlative wheat soils, wheat farmers who seemingly thought little of soil conservation now see what erosion is doing, and has done, on numerous slopes where the land's very steepness should have aroused at least a suspicion about the catastrophe that was taking place in their fields. Now field after field is being planted to grass and sweetclover or alfalfa, particularly where the soil has washed so thin that bedrock protrudes almost as much as in the "scabland" sections of the Big Bend of the Columbia River.

"Chiseling" the Stubble

Hill has a large number of farmers plowing their wheat stubble halfway under instead of burning it off as they formerly did. Moreover, many of them are chiseling wheat stubble so as to leave much of the stubble above ground, and leave the soil in a decidedly cloddy condition. There can't be much washing under such soil treatment, but no one knows just what will happen to the yield of the next grain crop. It may be depressed a little. Here we need experimental work to determine how deep to chisel, how much straw to leave above ground, when to disk, etc.

The erosion-control work in the bean and fruit districts of the Corralitos, Arroyo Grande, and Las Posas districts of southern California has definitely assured continuing stability to numerous ranches where conditions threaten to force abandonment of land worth from $300 to $1,000 an acre. In this general region, highly productive valley land is being

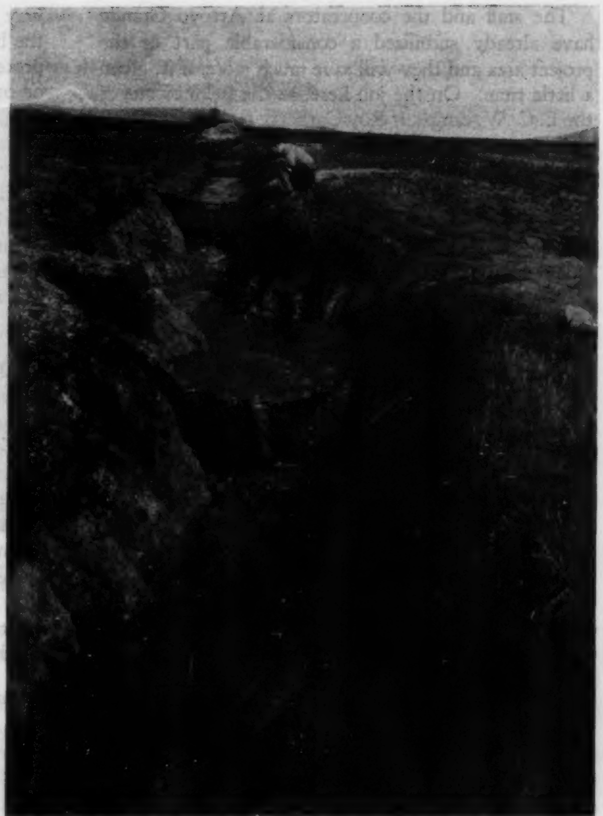
dissected with deep barrancas (California gullies) caused by excessive run-off of rain-water from adjacent unprotected steep slopes. The slopes themselves, which have been producing profitable bean crops, are splotched with brown clay areas from which the last inch of topsoil has been washed off—a process that changes good land to almost worthless land. A considerable acreage which has paid splendid dividends to its operators has already been farmed to the death state, while lowlands valued at $1,000 an acre are threatened by the deposition of relatively infertile material brought down with the increased run-off from erosion-exposed clay subsoil on the hillsides.

Cheap at the Price

I was somewhat disturbed about the costly appearance of a control job on a waterway in the Corralitos project. This waterway was doing great damage to the land—fine Yolo loam along the lower reaches and good sandy Moro Cojo soil upstream. It was almost 3 miles long, and the cost of its control, plus the supplemental work in adjacent fields, amounted to about $10,000. Here is approximately what we found from the lower end to the upper end near the crest of the watershed—the major installations and vegetative treatments:

A. Thirty-eight 5-foot control drops made of cement and rock rubble along a considerable length of the barranca;
B. Two thousand feet of vegetated, sloped sides, with numerous redwood drops;
C. About 1 mile of control with (*a*) waste oil field iron pipe and wire dams and (*b*) vegetated slopes;
D. About 1,400 feet of cement-lined gully;
E. About 900 feet of gully control with scrap-iron pipes and wire stabilization dams; and
F. About 2,500 feet of vegetated gully sides, with cement drops.

Ten thousand dollars on this job, of which the gully work roughly detailed above was the backbone, frightened me a little until I learned that by no other conceivable method was it possible to save the lands on this little watershed, in which a number of families live happily, and in which the land has a value of not less than $200,000. Erosion here was so rapid that we were able to photograph apple trees with deposits of erosional debris more than a foot above the crotch. Without this work I think 15 years would have seen most of the 500 acres permanently ruined, and an additional acreage downstream severely damaged by overwash.



A small gully in the Las Posas project being stabilized by dams made of mesh wire and tarred burlap. One rain has resulted in complete silting. This gully is now ready for the planting program.

Arroyo Grande was an "eye opener." I can think of no other place in the United States where erosion is any worse. Cultivation really got under way here about 10 years ago, but already many slopes have been destroyed and good bottom land buried with as much as 10 to 14 feet of sand. I saw a wire fence whose upper strand was partly covered by sand which had washed down from land worth from $150 to $200 an acre to cover land worth $400 to $500 an acre. This fence, with its upper strand covered, had been erected on top of another wire fence that had been covered previously in the same manner.

The staff and the cooperators at Arroyo Grande have already stabilized a considerable part of the project area and they will save much more of it, given a little time. On the job here, at the helm of one of the E. C. W. camps, is Roy Carberry—the man who is said to have steered the herculean undertaking to control the famous Colorado River break years ago—a job that saved Imperial Valley from inundation.

The farmers within these three projects are cooperating splendidly in the readjustments of land use called for under the erosion program. While I was in the State, one operator managing a tract of 822 acres of upland and valley land, most of it tilled, agreed to the retirement of 700 acres from cultivation so that erodible slopes might be stabilized with grass and trees.

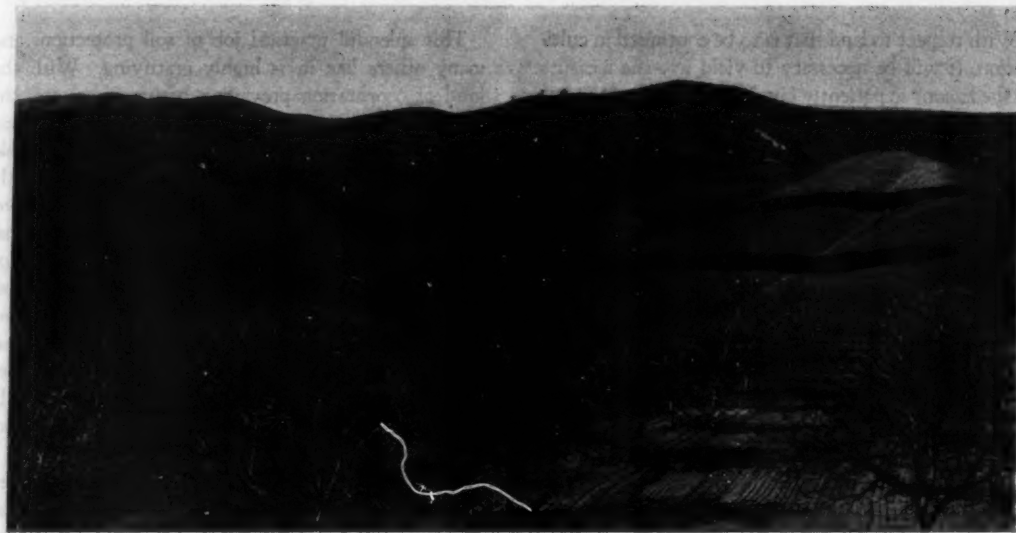
Fruit Trees on Contour

It is my opinion that probably the most efficient handling of cultivated, erodible slope land to be seen anywhere in the United States is to be found in the Las Posas-Santa Paula district. Here, on declivities frequently exceeding 30 percent, with a highly erodible soil, fruit trees are planted on the contour and cultivated in such manner as to develop a steplike topography. Eventually the trees grow about midway from bottom to top of the sloping face between the benches. These sloping faces are maintained in a protective cover of grass, alfalfa, Australian saltbush or other stabilizing vegetation, with cultivation and irrigation furrows restricted to the flat or upper part of the bench. Land thus treated lost no soil and very little water during a single cloudburst in 1934, when similar untreated plowed slopes lost in the neighborhood of 500 tons of soil per acre. Such an accomplishment is almost unbelievable until you study the details of this well-nigh perfect method of land stabilization.

Preserving Indian Lands

The work on the Navajo Indian Reservation has already gone far enough to indicate success with the program devised to preserve the lands and life of this tribe of Indians. At the Mexican Springs project, one tract of 50,000 acres brought under protection from overgrazing has made such recovery that much land which 3 years ago was largely bare of valuable forage plants is now so stocked with blue grama and western wheat grass that one Indian has actually cut a stack of hay from it. By a simple process of diking, storm water rushing out of the hills has been distributed in such manner that the silt has been caught and the

An excellent example of how gullying destroys valuable valley land in southern California.



Strip crops on bean fields, Ventura County, Calif. The walnut trees in the foreground are on high-priced valley floor land subject to damage by excessive run-off and wash-off from the steep slopes.

water absorbed by the flat, drought-plagued valley lands; and on these areas such recovery of grass has taken place that good hay could be mown from hundreds of acres. On some of this land a yield of corn in excess of 40 bushels an acre was predicted for this year's crop.

As rapidly as possible the entire Navajo Reservation of approximately 16,000,000 acres is being surveyed to determine the location and extent of areas available for spreading of run-off water and resultant protection against erosion. This method of water control absolutely stops arroyo cutting in the valleys and adds new soil to areas impoverished or depleted by wind and water erosion.

Nailing Down the Dunes

In the "dust bowl" of the Texas panhandle much land that seemed doomed to desert conditions last spring, when dust storms were ripping the plains to pieces, has been stabilized by listing, contouring, and seeding to adaptable soil-holding vegetation. Some of the recently-created desert areas are still drifting in dune formations, and are continuing to damage good land on the lee side. It is believed, however, that most of these wind-plagued areas can be controlled by nailing down the windward sides of the dunes with appropriate plantings of such crops as sorghum, Sudan grass, and small grain.

At one place on a 600-acre tract of 1935 desert, I was able on October 12 to collect approximately a quarter pound of drifting sand within 2 minutes by holding the end aperture of an ordinary envelop about 1 inch from the surface of the ground during a light breeze. Apply this rate of movement of the earth's crust to a considerable area, and you will gain some conception of what a splotch of newly created desert really means in the way of complete land instability and worthlessness.

Checking Wind Damage

I was greatly pleased with what I saw on the wind-erosion demonstration project near Huron, S. Dak. Real progress has been made in a short time. Farmers who were skeptical in the beginning have become enthusiastic supporters of the program. There is no question in my mind but that a really tremendous thing has been started here—the beginning of a new conception and a new practice of land use. This use aims fundamentally at the stabilization of land against impoverishment by wind but effective results call also for better utilization of rainfall. The basis of procedure is to provide adequate protection by using the various kinds of soil according to their specific needs and adaptabilities. Some highly erodible areas will have to go back to grass, or to the condition that nature employed to protect the entire Great Plains region for undeterminable thousands of years.

With respect to land that is to be continued in cultivation, it will be necessary to yield in some measure to the lessons so patiently taught by the wisest teacher of us all—"Mother nature." If all the land is stripped of vegetation and the soil kept finely pulverized with plows, there will be more and more blowing.

If we are to preserve these rich soils, part of the land must be kept under a protective cover of soil building, sheltering crops. This can be done in a strictly practical way by seeding strips of corn, grain, sorghum, sweet clover and small grains across the fields at right angles to the prevailing winds. Such a system can be made to give—has already given—nearly complete protection; and handled upon a rotation basis, it can be made to replenish the soil with the spongy, life-giving humus that was dissipated under the old system. This and other things are being worked into the regional farming systems in a thoroughly cooperative manner by the service staff and the farm operators.

Abandonment Forestalled

What has been done on the August Jungemann farm, near Wolsey, S. Dak., can be done on thousands of other farms in the Great Plains. Last spring the owner of this farm is reported to have decided on abandonment of the place, so disastrous had been the effects of soil blowing. The entire tract of 160 acres had been affected. Scarcely a sprig of vegetation remained. Loose, shifting sand was piled along the fences and about the buildings; yet this farm had supported the Jungemann family for more than a quarter of a century; two members of the family had gone to college on the products of the soil.

The owner did not, however, leave his farm. Now he is not likely to leave, for the farm has been saved and is rapidly being stabilized. The saving involved many things, with still others yet to be done.

Hampering hummocks of wind-drifted sand have been leveled down on about 140 acres; nearly 120 acres had to be listed as quickly as possible. Strip farming had been inaugurated on approximately 120 acres, with corn, small grain and sweetclover planted in rotation, with grass and alfalfa seeded in the irregular field corners. A 10-acre woodlot had to be cleaned up and sand drifts leveled along 2,500 feet of fence lines. About 20 acres will be retired to grass and something like 18 acres planted to trees to serve as windbreaks along the south, west, and north sides of the farmstead. Formerly there were only 2 fields on the place, 1 for small grain and 1 for row crops.

This splendid practical job of soil protection, and many others like it, is highly gratifying. With the kind of cooperation prevailing between farmers, the Service, and the State colleges of agriculture, success in the stupendous task ahead is certain. That task, however, is scarcely begun; it must be persistently pressed, improved, enlarged. Far-reaching achievement can be had only through continuing close cooperation on the part of citizens, farmers, erosion specialists, and State agricultural agencies. I am convinced that we are going to have just this kind of program; and through it, I am convinced also that these fertile lands, so indispensible to the continuing welfare of South Dakota and her sister States, will be given the protection without which tens of thousands of acres cannot be preserved.

Too bad we have lost another year in quantity collection of slender wheat-grass seed. W. A. Rockie had several areas for seed collection located on railroad lands, but lost his labor just as the seed matured in June. I saw the areas, and it is most painful to contemplate what we missed. Slender wheat is an excellent grass; it looks even better than crested wheat, at least in places, and crested wheat is a wonder in the Pacific Northwest. Think of it, we went to Asia to find crested wheat, and it was a great stride forward, to be sure. But in the meantime, we have generally overlooked a native grass—slender wheat—that covered millions of acres in Washington, Oregon, Idaho, and neighboring territory. Now we have a supply of crested wheat grass seed, the parents of which came from across the Pacific, but only a handful of the seed of a grass that grew on every hand over an enormous portion of North America before it was destroyed by plows and overgrazing.

New Farm Industry

Not so discouraging, however, has been the collection program with respect to the seed of numerous other native grasses and herbaceous plants with high erosion-control potentialities. Dozens of different kinds have been garnered in quantity this season. In the S. C. S. warehouse at Gallup, N. Mex., I saw an enormous stack of sacks plump with 1935 western wheat grass seed—60,000 pounds. In a little while these seeds will be in the ground doing their part toward stabilization of America's indispensable crop and grazing areas. And, in this connection, the harvesting of these hundreds of thousands of pounds of native seeds has created a new agricultural enterprise in these areas.

Mr. Bennett standing beside a wagon which is buried by sand washed from adjacent slopes. Arroyo Grande project, California.

In conclusion, my western swing convinced me that the fundamentals of practical erosion control through the use of the soil in accordance with its needs and adaptabilities are finding their way into the everyday practice of thousands of American farmers who a little while ago looked upon the word erosion as some vague expression familiar only to academicians. In retrospect, I find it difficult to understand for why so long we permitted vast areas, including some of the most fertile lands of America, to be washed away or blown away without evidencing any considerable interest, especially when it is considered that the methods of control now being used are so simple, so practical, and generally so inexpensive. Nothing is to be gained, however, by lamenting our failure to see and meet the problem 50 or 75 years ago. Now, finally, through this national program of coordinated, practical erosion control, and through the retirement of much erodible land to stabilizing cover under the program of the Agricultural Adjustment Administration, the path ahead to successful solution of the problem is clearly marked out. This western trip, which was my first opportunity to make anything like a comprehensive inspection of the field program of the Service, has convinced me that our program is so sound, so practical, so effective, and so inexpensive that this sensible Nation will permit no obstacle to interfere with its progress. Everywhere I found that splendid cooperation was being received from the State agricultural colleges, the county agricultural agents, the farmers, and local business men.

Research Needed

We do not yet know, of course, all that should be known about how best to handle certain types of land within the various climatic and soil regions. Much experimental work remains to be done. We are finding that subsoiling is an effective measure for increasing absorption of water and thereby reducing erosion on some soils under certain types of rainfall, and of no value whatsoever under other conditions; we do not know, however, the limitations of this method of controlling erosion by increasing infiltration of meteoric waters. Nor do we know how best to handle

crop residues, such as small grain stubble, so as to leave some protective portion of the vegetation above ground in our cultural operations. Much remains to be learned about the most advantageous methods of utilizing strip cropping, which is accomplishing such an effective job of erosion control on many types of soil. It is not known, for example, how wide the strips should be on the steeper slopes or at just what declivities strip cropping should be supported by terracing.

These are but a few of the numerous things that we should know and can know only through research, or by trial and error. Without delay, these major uncertainties should be subjected to the scrutiny of research on a regional basis, in close cooperation with the State agricultural experiment stations.

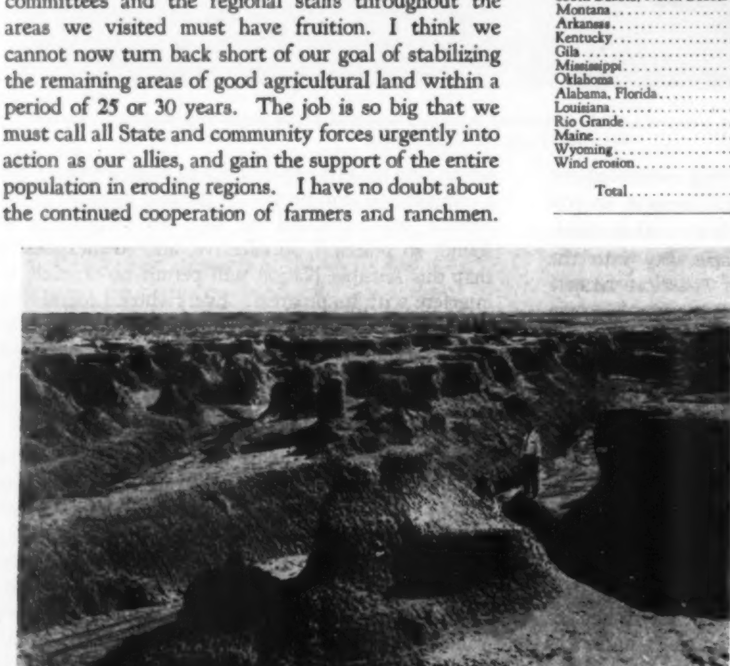
Proceeding in the foregoing direction, again I want to repeat that the way to a successful solution of the erosion problem of the United States seems clear enough. The ability, enthusiasm, and energy of the field forces of the Service have been a major force, I am sure, in bringing about this infant revolution in correct land utilization. Such fine cooperative spirit as that manifested by members of the State advisory committees and the regional staffs throughout the areas we visited must have fruition. I think we cannot now turn back short of our goal of stabilizing the remaining areas of good agricultural land within a period of 25 or 30 years. The job is so big that we must call all State and community forces urgently into action as our allies, and gain the support of the entire population in eroding regions. I have no doubt about the continued cooperation of farmers and ranchmen.

EMPLOYMENT OF RELIEF LABOR

Progress in the transfer of labor from relief rolls to the Soil Conservation Service is reflected in a statistical summary issued as of October 19.

The report shows that 14 units had exceeded their quotas on that date.

State, watershed, or area	Number of relief workers	Relief labor quota	Regional director	Percent of relief labor quota
New Jersey	589	268	Lee	219.4
Kansas	548	293	Duley	187.0
New York	731	420	Howe	174.0
South Carolina	1,345	775	Buie	173.5
Pennsylvania	838	489	Patrick	171.4
Nursery	496	301	Enlow	164.8
Colorado	953	649	McClymonds	146.8
Illinois	422	337	Fisher	125.2
East Texas	556	450	Merrill	123.6
Wisconsin, Minnesota	524	431	Davis	121.6
Virginia	441	374	Keil	117.9
Georgia	917	795	Rast	115.3
Nebraska	229	200	von Trebra	114.5
Iowa, Missouri	1,091	1,068	Uhland	102.2
Oregon, Idaho				
Washington	397	405	Rockie	98.0
North Carolina	1,298	1,349	Stallings	96.2
California, Nevada	859	911	Reddick	94.3
Ohio, West Virginia				
Indiana, Michigan	912	1,020	Cutler	89.4
Maryland	152	185	Bruce	82.2
Central Texas	456	647	Geib	70.5
Navajo	903	1,296	Matthews	69.7
South Dakota, North Dakota				
Montana	540	780	Clemmer	69.2
Arkansas	582	888	Sargent	65.5
Kentucky	159	314	Alberts	50.6
Gila	678	1,389	Fleming	48.8
Mississippi	356	758	Anders	47.0
Oklahoma	412	888	Winters	46.4
Alabama, Florida	262	588	Bailey	44.6
Louisiana	262	669	Mims	39.2
Rio Grande	352	926	Smith	38.0
Maine	337	116	Patrick	31.9
Wyoming	38	370	McClymonds	10.3
Wind erosion	98	1,042	Finnell	9.4
Total	18,433	21,552	Average	85.5



Badlands of the San Simon Wash, Arizona, where erosion has taken its toll.

LIME AS A FACTOR IN SOIL CONSERVATION

By Sidney P. Armsby

Lime plays an essential part in soil conservation. Its benefits are cumulative in effect.

Quite generally soils which are noticeably acid are also markedly deficient in humus and have very little water-retaining capacity. This is particularly true in western Pennsylvania, where the soils are derived principally from the weathering of shale and sandstone. On many of the badly eroded slopes of this area we find gravelly or shaly soils, loams or silt loams practically devoid of organic matter, strongly acid, and with very little ability to absorb and retain water. Such soils are simply "floated" away by run-off water unless checked by vegetation or by artificial means.

When such a soil is limed, however, and planted to the first crop of a properly planned rotation, an important series of changes is instituted. The first visible effect of the lime treatment is a heavier growth of vegetation—corn, wheat, clover, or whatever it may be. This heavier growth, in turn, provides a larger bulk of material of a fibrous character (roots, stems, and leaves) more or less firmly anchored. Considered purely from a mechanical viewpoint, this material acts like a network of minute check dams—holding back the light soil particles and thereby retarding erosion This retarding effect is progressive as the crop matures because the total mass of vegetable material is constantly increasing.

Stubble to Humus

There is a larger quantity of stubble left in the lime-treated field than would have been possible had the soil not been limed, and when this decomposes, humus is produced and the water-absorbing capacity of the soil is increased. During the following season the soil will not wash so easily; crops will grow better because of the retained moisture; a larger root system will be developed by the growing crop, and this favors percolation and retention of more soil in place. Then, as season follows season—and assuming that proper replacement is made of the lime and other materials (both mineral and organic) removed in the harvested crops—the process continues at an accelerated rate, up to the point of maximum efficiency.

Development of soil acidity is prevented; larger crop yields are obtained; humus reserves are built up, and what was originally not much better than loose, powdery "dirt" often becomes a real soil—firm in texture, able to absorb and retain moisture, highly productive, and much less subject to erosion.

The value of organic matter in this connection is well illustrated by tests made on Marshall silt-loam soil at Clarinda, Iowa,[1] covering a period of approximately 18 months, during which there was a total precipitation of 40 inches. On an 8.8 percent slope a check plot in corn with no treatment showed a 15 percent run-off, a soil loss of 50 tons per acre, and a corn yield of 40 bushels per acre. A similar corn plot on the same slope, in which green sweetclover was grown and plowed under, showed a run-off of 7 percent, a soil loss of 8 tons per acre, and a corn yield of 100 bushels per acre. Thus the moisture loss was reduced over 50 percent; the soil loss, or erosion, was reduced more than 80 percent, and the crop yield was increased 250 percent.

Liming Retards Erosion

This test emphasizes the value of lime in erosion control. A soil which has been built up by crop rotation and the proper use of lime is much less subject to erosion. A good solid stand of bluegrass, alfalfa, or clover, grown in a properly limed soil, affords almost perfect protection against water erosion, even on very steep slopes.

Thus, liming the soil occupies a key position in the activities of the Soil Conservation Service. It is essential as a plant food; its correct use increases the profits from farming operations and promotes the proper use of agricultural land. And, at the same time, it serves as a valuable "tool" for use in the campaign against the farmer's arch enemy—soil erosion.

Erosion must be controlled before soil fertility can be increased.

More than 40 percent of the soil wealth is contained in the top six inches of soil.

Erosion has caused streams to dry up, resulting in the disappearance of fish, animal, and bird life.

Retiring from cultivation all badly eroded submarginal lands and planting them to either grass or timber is an effective means of securing best land utilization.

The Romans noted the folly of growing the same crops on the same land for several consecutive years.

[1] H. H. Bennett—Transactions. American Geophysical Union, 1934.

DAMS THAT GROW

By Albert Chiera

(Editor's note.—Soil science, which knows no international boundaries, finds it useful now and then to take a look into other parts of the world. In so doing, it does not commit itself to practices prevailing elsewhere but simply adds to its own treasury of information. This article, with its very interesting pictures, is a byproduct of extensive reading of erosion-control literature by the author, who is a translator and research assistant for the Soil Conservation Service)

There are two ways of checking unruly waters: By vegetation when the flow is moderate, by dams when the flow is more impetuous.

One might infer from this arbitrary statement that dams, being employed against more violent falls, would serve their purpose unfailingly unaided by vegetation. Such a conclusion would be in error.

In Italy from 1870 to 1910 the enormous expenditure of 700,000,000 lire was devoted to restraining waters by dams and other artificial methods. Only a few hundred lire went into reforestation. The results have been entirely disproportionate. G. Di Tella illustrates this fact by numerous examples of mountain streams in which dams were used unsuccessfully ("L'Alpe" Rivista Forestale Italiana; May 1931). The state of these mountain streams tells the story of the frequent failure of the dam method when unassisted by vegetation.

It often happened that dams alone were rendered useless by being covered up by materials washed from the mountain sides. New masonry dams were built, and vegetation was established on the side slopes, to resist scouring by erosive waters and to prevent slides.

First of all, the slope which was originally rough because of erosion was graded and made even, so that the water might spread and flow smoothly, gently down the sides. Wattled or willow dams and fascines were then set in diagonal and horizontal lines across the slope.

The pictures point to the success of the plan. It shows the watershed at the right of the torrent Cava Fasaniello, in the Province of Naples, partly restored

(Continued on page 18)

THE PICTURES

Opposite page, top.—*A view of the torrent Cordarezzo, near Piacenza, showing the inability of dams unsupplemented by vegetation to bind the earth in this region. Slides and debris have all but obliterated the masonry structures and have rendered them useless in erosion control.*

Opposite page, bottom.—*Another view of the Cordarezzo, after engineering treatment of the mountain slope for the establishment of fascines and wattles, and renovation of the series of dams.*

This page.—*A lattice work of live willow branches, thrifty and well established within the short space of 4 months, holding soil in place, assisting other vegetation to obtain a foothold, keeping run-off water from rushing down the slopes to wreak such destruction as that shown in the top picture on the opposite page.*

DETENTION RESERVOIRS FOR GULLY CONTROL

By Dwight D. Smith and Emerson Wolfe

Due to the fact that large gullies exist on comparatively small drainage areas in the Big Creek watershed in Missouri, it soon became apparent that the cost of the conventional type of masonry and cement structures could not be justified on an acreage basis. Since the amount of water to be handled was comparatively small, it was thought possible to design a detention reservoir which would be capable of storing the run-off from the average hard rain and discharging it slowly to the bottom of the gully.

Meeting the Problem

An earthen dam with a small tile drain supplemented by an emergency side spillway at a higher level seemed a good solution to this problem. In order correctly to design these structures, rainfall data including amounts and intensities for this area were consulted. From this the required storage capacity and the necessary rate of discharge from the tile drain were determined. It was decided to design a detention reservoir so the emergency side spillway would be used on an average of about once in 2 years. This period of time allowed economical construction and seemed ample to enable vegetative protection to establish itself. Another factor in favor of this type of structure was the high clay content of the subsoil of the Grundy-Shelby series on which we were working. Also, machinery was available to move earth econom-

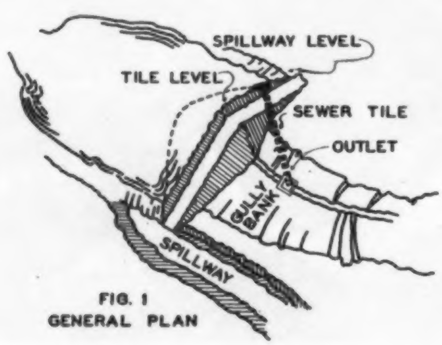


FIG. 1
GENERAL PLAN

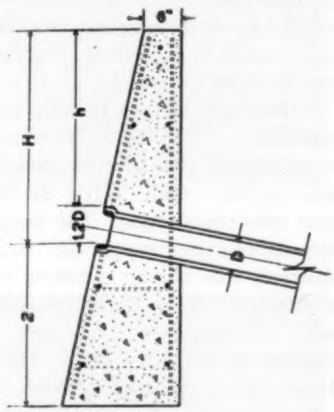


FIG. 2
INLET PLAN

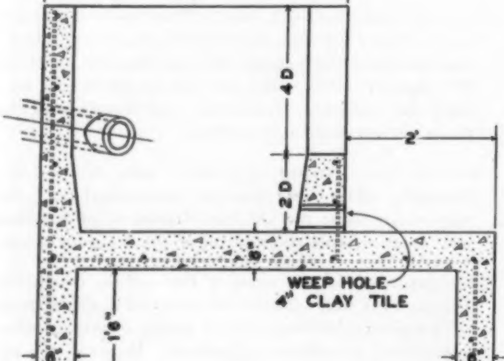


FIG. 3a

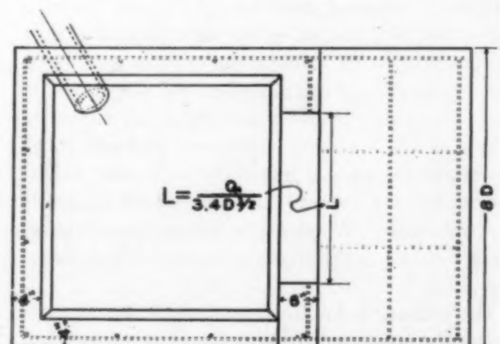


FIG. 3b

OUTLET PLAN

ically. This is an important factor and may influence the design or even make the use of some other type of structure more practical.

In general, the method of construction of the dam proper follows conventional practices. Whether or not the dam is constructed before the tile is laid will depend upon the individual problem at hand. If the dam is to be several feet higher than the inlet to the drain it is usually best to put the tile in place first. If it is to be only a few feet higher than the inlet, the tile is best installed after the dam is built in order to eliminate the danger of damage or breakage of the tile during the construction of the dam.

Adequate Storage Capacity

The dam and the emergency side spillway must be enough higher than the existing overfall in the gully to provide adequate storage capacity. The tile drain is best located at one end of the dam on solid ground. (See fig. 1.) The emergency side spillway must be large enough to handle the maximum run-off from the drainage area and should be protected by an adequate vegetative cover. Sewer tile, laid entirely on solid ground, with joints cemented or packed with treated oakum and asphalt, has proven to be the most satisfactory drain, cost considered. The tile should be laid on an even grade and cradled to at least the quarter point. All changes in grade should be made on a vertical curve. Seep collars around the tile should be provided where it is thought necessary to prevent seepage working down along the tile line.

The inlet consists of a reinforced concrete headwall with a bell-mouthed orifice to reduce entrance loss into the tile. (See fig. 2.) Several types of outlets have been used and each utilizes a water cushion as a means of destroying the velocity of the water. Figure 3a shows a cross-sectional view and figure 3b shows a top view of a type of outlet design.

The size of the drainage area is one of the limitations of these structures and is relative to the available storage capacity. Storage capacity must be obtainable without too great a height on the dam. The soil type must be adapted to earthen reservoir construction. These dams are more satisfactory on pasture or terraced drainage areas where the rate of silting is low.

The engineering section on the Big Creek demonstration project has workable formulas for computing the storage capacity needed and the discharge rate required.

OREGON DUST SPOTS LOCATED BY PLANE PILOTS

Aviation has added its plea for wind erosion control. Pilots of airplanes flying between Pendleton and Portland, Oreg., have reported the impossibility of landing at times, owing to dust. With ground winds at 15 miles an hour or higher, these pilots have observed that most of the dust blowing comes from 10 or 12 spots easily identified from the air. The greater part of this dust, they have stated, comes from areas other than cultivated farm land.

Business men have joined with air lines in asking that the Soil Conservation Service survey "blow" areas in northern and central Oregon with a view to curbing the dust storms which make plane landings hazardous and living conditions unpleasant.

DAMS THAT GROW

(Continued from page 11)

by vegetation of only 4 months' growth. At the summit the work must yet be completed.

A detailed description of the way in which this work is actually done is given by C. Valentini in his book Control of Torrents and Mountain Basins. He offers some suggestions as to the construction of these wattles or fascines intended to protect vegetation during its early stages.

"Wattles" are built by driving in the ground green willow stakes that are expected to germinate and are arranged as a palisade. This forms the frame of the living dam which is interwoven with long willow branches in the same manner as a basket. They are generally about 20 inches high and placed at suitable intervals apart. Each structure is defended against the impact of run-off waters by a small earthen bank placed in front to support it; over this bank shoots of willow are also planted. Between successive willow dams are planted shoots of elm, ash, and maple.

When higher dams are required, the stakes are of larch or of species equally strong. For plants intended to sprout, when willow is not available, recourse is taken to spruce, hazel, and alder.

"Fascines" are very similar to wattles, with one difference. Instead of the branches being interlaced, they are bunched and tied together and then laid back of the palisade, thus forming the fascine.

Excess water not absorbed by vegetation is carried off in sluiceways to the foot of the slope. These are protected against water erosion by stones.

PLANTS OF PROMISE IN GULLY SLOPE PROTECTION

By Henry E. Collins

Gila River Project, Safford, Ariz.

Cactus plants set above brush riprap. Easily transplanted in desert washes, they serve a useful purpose in collecting silt.

On the upper Gila River watershed erosion is so severe that climax vegetation is insufficient to reestablish a cover. The year's precipitation, averaging 12 inches or less, is largely confined to winter and midsummer, following three months of extremely dry weather in the spring. Torrential summer downpours have caused a badly gullied condition and washed off much of the top soil, allowing invasion of the slopes by plants of low value in producing forage and controlling erosion. One of these plants is *Haplopappus sp.* (Jimmyweed) and others are *Gutierrezia spp.* (Snakeweed) and *Opuntia stanleyi* (Devil cactus).

It is apparent under such conditions, as for instance the deeply creased San Simon Valley, that an important move in erosion control is slope protection. Alone or in conjunction with mechanical methods, the reestablishment of vegetation along the banks of gullies and streams is of prime importance.

Fortunately, there are available a number of plants of heavy root system and rapid growth which may be easily established. The extreme conditions prevailing and the urgency of effective control, suggest the use of plants which may be readily established irrespective of their value for other purposes.

The following findings, although covering a comparatively short period and specific conditions, indicate what may be expected. Of outstanding significance is the fact that fall and winter transplanting gave most generally satisfactory results because of the greater precipitation and less evaporation which occur at these seasons. It was also found that best results in check dam plantings were had after one summer of filling.

Tamarix gallica (salt cedar).—This species, found growing abundantly along the Gila and Salt Rivers, is now becoming established in the washes in the San Simon Valley. It is being used successfully as bank protection by a railroad along the Little Colorado River in northern Arizona. The plant is browsed by stock to some extent but recuperates rapidly and withstands being covered by silt. Although rather drought resistant, it does not propagate and spread readily unless favored by underground moisture. The fact that it propagates readily from cuttings and makes a rapid growth should make it valuable for stream and large wash bank protection.

Thirty-six rooted cuttings were set in the main drainage canal of the San Simon Valley March 27, 1935, with a loss of only 10 percent. Also several

rooted cuttings were planted behind check dams on the erosion-control projects of the Papago Indian Reservation in the fall of 1934 with good results. Unrooted cuttings have also been grown successfully.

A Fast-Growing Tamarisk

Tamarix aculeata (Athel tree).—This tamarisk is much faster growing than gallica. It also is browsed to some extent by cattle and attains sufficient size to furnish firewood and posts. Like the salt cedar, it propagates readily from cuttings and, with its heavy root system, is equally satisfactory for bank protection. It is, however, less hardy, which restricts its use to the warmer areas.

Out of 300 cuttings, varying in size from very small ones to 3 or 4 inches in diameter, set out on the San Xavier Indian Reservation in January 1935, about 95 percent grew successfully. These cuttings were planted behind check dams in small gullies.

Baccharis glutinosa (Bata mote).—This medium-size, fast-growing shrub also appears to have an important place in stream-bank protection and in gully work where there is some accumulation of underground moisture. The plant is found in large quantities along the Gila River and is becoming established in the San Simon wash. It propagates readily from cuttings or rooted transplantings and withstands flooding, but is only sparingly browsed by stock.

Of 3,000 rooted cuttings planted behind check dams on the San Xavier Reservation in January 1935, about 90 percent grew successfully. On March 27, 1935, 36 cuttings were set in the San Simon wash, of which 85 percent are growing.

This Is Easily Transplanted

Aster spinosa (Spiny aster).—This stoloniferous perennial transplants readily, is deep rooted and withstands heavy flooding and silting.

In a planting of 3,000 rooted cuttings set behind check dams on the San Xavier Reservation during January 1935, about 90 percent grew satisfactorily. Out of 30 rooted cuttings set in a diversion canal near Safford on February 28, 1935, 75 percent are growing as are 36 cuttings set in the San Simon wash.

Chilopsis linearis (Desert willow).—Desert willow is common in large desert washes within its altitude range. It is effectively checking erosion here, as well as in steep canyons. Although not classed as a grazing plant, the spring foliage is eaten by stock. Young seedlings and rooted cuttings transplant readily, and the plant is considered of outstanding value for gully-erosion control.

One hundred and thirty-four rooted cuttings were set out behind erosion structures in gullies in January of this year, 110 of which are growing. Of 150 transplantings in the diversion dam area near Safford last December, 90 percent have become established.

Clematis drummondii (Silk vine).—This woody vine is a rapid grower. In many cases it is proving effective in checking gully erosion. It is tolerant of shade but is often found in exposed situations. That it may be readily transplanted is indicated by the fact that of 100 plants set behind check dams at San Xavier in January 1935, no loss was sustained.

Hymenoclea monogyra (Burro brush).—Common in desert washes and foothill canyons, this is effectively controlling erosion and in some cases actually causing gullies to fill with silt. The plant may be grown readily from uncalloused stem cuttings or seed. Numerous test plantings along gullies, from cuttings, were entirely successful.

Black Willow Binds Well

Salix nigra (Black willow).—Several large, post-size cuttings of black willow were used as binders for check dams near Artesia, Ariz., in the fall of 1934, most of which are growing. Thirty-six stem cuttings were set in the San Simon wash and 25 in the Freeman wash in the spring of 1935, with a 50 percent catch. Even where post-cuttings fail to take root they have been found to last 3 to 4 years.

Capriola dactylon (Bermuda grass) is found to be coming in from seed behind erosion control structures, both on the Papago Indian Reservation at an elevation of 2,500 feet and near Safford at an elevation of 3,900 feet. Root transplantings, in the San Simon wash and in Freeman Flats, took hold and are spreading.

Holcus halepensis (Johnson grass).—This grass was established on the Papago Reservation in the desert washes by seed sown in November 1934. A large-scale experiment, made by a rancher near Tucson, was successful in establishing this grass from root cuttings with the aid of contour furrows.

Johnson grass is common along the Gila River and all adjacent irrigation canals. Consequently, infestation has ceased to be a potential threat in this area.

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KUDZU AIDS IN GULLY CONTROL

Claude C. Hamilton, who lives on the old family farm nine miles northeast of Forrest City, Ark., finds kudzu effective in gully control.

In 1923 a single crown of kudzu was obtained from Alabama. It was transplanted near a wide and deep gully near the farmhouse and just across the road from his large peach and apple orchard. The vine began to grow and spread. It now lines the gully and covers its bed to a distance of 100 feet. It has climbed trees near by and threatens to kill them. The road grader seems to be responsible for keeping the kudzu cut back and protecting the peach trees on the other side of the road.

Mr. Hamilton said that the kudzu vines have gone through at least three fires and have survived and spread and vegetated the gully despite these destructive agencies. Although the gully is still about 15 feet deep, it is rapidly being stabilized by the cover vegetation.

Kudzu is a leguminous plant which endures poor soil on badly eroded areas. Under usual conditions, it grows fast and the foliage is so dense that one season's growth goes far toward controlling erosion. Conservation specialists set the crowns around the rim of a gully and behind the check dams. The vines will usually grow down the banks and affix themselves over the entire face and channel.

Kudzu vine may be used moderately for grazing. The foliage is of high protein content and is relished by livestock.

Growth of kudzu from single crown planted on the Hamilton farm in 1923.

PLANTS OF PROMISE IN GULLY SLOPE PROTECTION

(Continued from page 15)

Atriplex canescens, *A. polycarpa*, *A. lentiformis*, *A. linearis* (salt bushes) have proved in past experiments to be fast growing from seed when planted in flood plain areas in the Southwest. Seeds of these plants are usually viable and are easily gathered. All salt bushes are browsed to some extent by stock and the large root system is ideal for gully erosion control. Seeding experiments, in the Freeman Flat area and on the Papago Reservation, indicate that the plants can be readily established by direct seeding.

Valota saccharata (cotton top), *sporobolus airoides*, (Sacaton) and *Andropogon saccharoides* (feather grass) usually give a high percentage of viability in germination tests. With the additional moisture made available by check dams, indications are that these grasses would become established by direct seeding.

One thousand sod clumps of each of these grasses were set behind erosion-control structures on the San Xavier project in January 1935, and at present 95 percent of each have become established. Both the cotton-top and sacaton grasses are considered excellent feed and observations indicate that these grasses would grow under all conditions found on the San Simon watershed.

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